(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
30 September 2004 (30.09.2004)

PCT

(10) International Publication Number
WO 2004/083466 A1

(51) International Patent Classification[7]: C21D 9/56, 11/00, C23C 2/40, 2/06

(21) International Application Number: PCT/AU2004/000346

(22) International Filing Date: 19 March 2004 (19.03.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2003901298 19 March 2003 (19.03.2003) AU

(71) Applicant (*for all designated States except US*): BLUESCOPE STEEL LIMITED [AU/AU]; Level 11, 120 Collins Street, Melbourne, Victoria 3000 (AU).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): RENSHAW, Wayne [AU/AU]; 29 Coachwood Drive, Unanderra, New South Wales 2526 (AU). WONG, Sean [AU/AU]; 82 Madigan Boulevard, Mount Warrigal, New South Wales 2528 (AU).

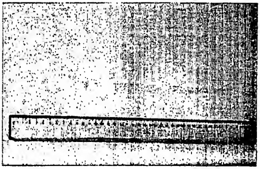
(74) Agent: GRIFFITH HACK; 509 St Kilda Road, Melbourne, Victoria 3004 (AU).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

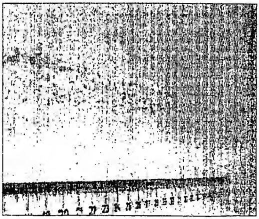
(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),

[Continued on next page]

(54) Title: METAL-COATED STRIP



a



b

(57) Abstract: A method of producing a metal-coated, recovery annealed, and thereby high tensile strength, steel strip is disclosed. The includes the steps of heat treating the steel strip in a heat treatment furnace (5), thereafter hot-dip metal coating the strip in a bath (6) of molten coating metal and thereby forming a metal coating on the steel strip, and thereafter conditioning the surface of the metal-coated steel strip at a conditioning station (8) by smoothing the surface of the strip. The method is characterised by controlling the temperature of an outlet end section of the heat treatment furnace to be (i) sufficiently high to minimise condensation of metal vapour in the outlet end section and/or (ii) substantially constant to minimise destabilisation of metal/metal oxide deposits on the walls of the outlet end section that could release deposited material onto strip passing through the outlet end section.

Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

METAL-COATED STRIP

The present invention relates to metal-coated, steel strip.

The present invention relates particularly but not exclusively to metal-coated, recovery annealed, and thereby high tensile strength, steel strip that is suitable for use as a paint line feed.

The term "recovery-annealed" is understood herein to mean steel strip that has been heat treated so that the microstructure undergoes recovery with minimal, if any, recrystallisation, with such recrystallisation being confined to localised areas such as at the edges of the strip.

The present invention relates particularly but not exclusively to recovery annealed, and thereby high tensile strength, steel strip that has a corrosion-resistant metal coating and can be painted and thereafter cold formed (e.g. by roll forming) into an end-use product, such as roofing products.

The present invention relates particularly but not exclusively to recovery annealed, and thereby high tensile strength, steel strip that has a corrosion-resistant metal coating on the strip and a paint coating on the metal coating.

The present invention relates particularly but not exclusively to a corrosion-resistant metal coating in the form of a aluminium/zinc alloy.

The present invention relates particularly but not exclusively to metal-coated, recovery annealed, and thereby high tensile strength, steel strip that is produced

by a hot-dip coating method.

In the conventional hot-dip metal coating method, steel strip generally passes through one or more heat treatment furnaces and thereafter into and through a bath of molten coating metal, such as an aluminium/zinc alloy, held in a coating pot. The furnaces may be arranged so that the strip travels horizontally through the furnaces. The furnaces may also be arranged so that the strip travels vertically through the furnaces and passes around a series of upper and lower guide rollers. The coating metal is usually maintained molten in the coating pot by the use of heating inductors. The strip usually exits the heat treatment furnaces via an outlet end section in the form of an elongated furnace exit chute or snout that dips into the bath. Within the bath the strip passes around one or more sink rolls and is taken upwardly out of the bath. After leaving the coating bath the strip passes through a coating thickness station, such as a gas knife or gas wiping station at which its coated surfaces are subjected to jets of wiping gas to control the thickness of the coating. The coated strip then passes through a cooling section and is subjected to forced cooling. The cooled strip thereafter passes successively through a skin pass rolling section (also known as a temper rolling section) and a tension levelling section. The skin pass rolled and levelled strip is coiled at a coiling station.

The main purpose of conventional skin pass rolling strip is to condition the strip surface (with minimal thickness reduction) to smooth the surface. A smooth strip surface is important in order to produce a high quality painted surface on metal-coated strip.

The main purpose of conventional tension levelling strip is to deform the strip so that it is sufficiently flat for subsequent processing, for example in

a paint coating line operating at high speed (i.e. at least 100m/min).

The applicant has found that producing metal-coated steel strip, particularly recovery annealed, and thereby high tensile strength, steel strip with minimal residual stress, ie residual stress of no more than 100 MPa, makes it possible to consistently and reliably roll form the strip. This invention is an important invention from the viewpoint of being able to provide end users of strip, ie the roll-formers, with consistent quality strip. This invention is the subject of Australian complete application 43836/01 in the name of the applicant.

In the context of the present invention, "residual stress" is understood to mean the residual stress through the thickness of the strip. Accordingly, references to "residual stress" herein should be understood as references to through-thickness residual stress.

The applicant has also found that in order to produce strip with minimal residual stress it is necessary to skin pass roll and tension level under different conditions than were used previously, with the overall result that the strip is rolled relatively lightly.

The applicant has also found that recovery annealed, and thereby high tensile strength, strip coated with an aluminium/zinc alloy that is produced under these relatively light rolling conditions is more susceptible to a particular type of surface defect than high tensile strength aluminium/zinc alloy-coated strip produced in conventional skin pass rolling and tension levelling conditions. The present invention is concerned with minimising this surface defect.

There are 2 main types of the surface defect.

Figures 1, 2a and 2b are photomicrographs of both types. Both types of the defect are caused by Zn and ZnO dust particles that are deposited on steel strip prior to applying a metal coating to the strip.

The type of the defect shown in Figure 1 is a dent/depression/half buckle that has a comet-shape, with the head of the comet pointing in the forward direction of travel of the strip. Typically, the defect is 20-50mm wide and 50-150mm long. This defect is caused typically by Zn dust which deposits onto the strip prior to the strip passing through the molten metal coating bath.

The type of the defect shown in Figures 2a and 2b is an area of rough coating with very small pinholes that have the appearance of narrow streaks. Typically the defect is 10-90mm wide and 200-3000mm long and may be associated with a buckle. This defect is caused typically by an "avalanche" of ZnO dust which deposits onto the strip prior to the strip passing through the molten metal coating bath.

It is noted that the defect forms on strip that is subsequently processed by conventional skin pass rolling and tension levelling conditions. However, the defect or the appearance of the defect tends to be removed at least partially by subsequent conventional tension levelling of the skin-passed rolled strip.

The defect is undesirable from the viewpoint of the aesthetic appeal of the strip. Defective strip is generally scrapped - and this is costly and wasteful.

In addition, the defect has an impact on the line speed of paint lines. Specifically, the defect makes it necessary to operate paint lines at lower speeds than would normally be the case in order to ensure proper coverage of

the strip with paint.

The applicant has also found that the Zn and ZnO dust particles tend to be the result of condensation of Zn vapour as Zn or ZnO particles onto cooler sections of the elongated furnace exit chute or snout of the heat treatment furnaces that is immediately upstream of the coating pot in the direction of movement of the strip and subsequent release of the condensed particles onto strip passing through the chute or snout at that time. The Zn vapour originates from the coating pot.

The applicant has also found that there is increased release of Zn or ZnO particles when there are changes in production line operating conditions, particularly temperature, in the chute or snout and changes due to processing different grades of steel, which destabilise and thereby result in release of particles from existing built-up layers of Zn/ZnO deposits on the walls of the chute.

The present invention is based on the realisation that the formation of the surface defect from deposition of Zn or ZnO particles on recovery annealed, and thereby high tensile strength, strip passing through the elongated furnace exit chute or snout can be minimised by controlling the temperature in the chute or snout to be sufficiently high to minimise condensation of Zn vapour onto the walls of the chute or snout and/or to be substantially constant to minimise destabilisation of Zn/ZnO deposits on the walls of the chute or snout that could result in the release of already-deposited material onto strip passing through the outlet end section.

In this context, "minimal surface defects" is understood herein to mean that there is no more than 1 defect of the types shown in Figures 1 and 2 per 500 lineal

meters of metal-coated steel strip.

In addition, in this context, "substantially constant" is understood to mean a temperature variation of no more that 20°C.

With the above in mind, according to the present invention there is provided a method of producing a metal-coated, recovery annealed, and thereby high tensile strength, steel strip which includes the steps of successively passing the steel strip through a heat treatment furnace, a bath of molten coating metal, and a conditioning station, and:

(a) heat treating the steel strip in the heat treatment furnace;

(b) hot-dip metal coating the strip in the bath of molten coating metal and thereby forming a metal coating on the steel strip; and

(c) conditioning the surface of the metal-coated steel strip at the conditioning station by smoothing the surface of the strip, and

which method is characterised by controlling the temperature of an outlet end section of the heat treatment furnace to be (i) sufficiently high to minimise condensation of metal vapour in the outlet end section and/or (ii) substantially constant to minimise destabilisation of the metal/metal oxide deposits on the walls of the outlet end section that could release deposited material onto strip passing through the outlet end section.

According to the present invention there is also provided a method of producing a painted, metal-coated, recovery annealed, and thereby high tensile strength, steel

strip which includes the steps of successively passing the steel strip through a heat treatment furnace, a bath of molten coating metal, a conditioning station, and a paint line and:

(a) heat treating steel strip in the heat treatment furnace;

(b) hot-dip metal coating the strip in the bath of molten coating metal and thereby forming a metal coating on the steel strip;

(c) conditioning the surface of the metal-coated steel strip at the conditioning station by smoothing the surface of the strip; and

(d) forming a paint coating on the conditioned strip in the paint line, and

which method is characterised by controlling the temperature of an outlet end section of the heat treatment furnace to be (i) sufficiently high to minimise condensation of metal vapour in the outlet end section and/or (ii) substantially constant to minimise destabilisation of metal/metal oxide deposits on the walls of the outlet end section that could release deposited material onto strip passing through the outlet end section.

The temperature of the outlet end section of the heat treatment furnace may be kept sufficiently high by controlling the upstream operating conditions within the furnace.

The temperature of the outlet end section of the heat treatment furnace may be kept substantially constant by controlling the upstream operating conditions within the furnace.

Specifically, in a situation in which there is a need to change the heat treatment profile of strip in order to produce strip that has different mechanical properties to immediately preceding strip, the method includes controlling the heat treatment profile of the strip in one or more sections of the furnace that are upstream of the outlet end section to adjust the mechanical properties of the strip as required and without substantially changing the temperature in the outlet end section.

The temperature of the outlet end section of the heat treatment furnace may be kept sufficiently high by appropriate selection of insulation material for the outlet end section to minimise heat loss within the outlet end section.

The temperature of the outlet end section of the heat treatment furnace may be kept substantially constant by appropriate selection of insulation material for the outlet end section to minimise heat loss within the outlet end section.

Preferably the metal of the metal coating is a aluminium/zinc alloy and the metal/metal oxide deposits are Zn/ZnO deposits.

Preferably the aluminium/zinc alloy contains at least 30% by weight aluminium.

Preferably the method includes controlling the wall temperature of the outlet end section of the heat treatment furnace to be at least 450°C.

Preferably the method comprises controlling the wall temperature of the outlet end section of the heat treatment furnace to be at least 480°C.

Preferably the method includes controlling the wall temperature of the outlet end section of the heat treatment furnace to be within a temperature range of 40°C, more preferably 20°C.

The furnace may be any suitable furnace, such as a horizontal furnace or a vertical furnace.

Preferably the furnace has an elongated furnace exit chute or snout that extends into the bath.

The term "high tensile strength" is understood herein to mean that the tensile strength is at least 450 MPa.

More preferably the tensile strength of the steel strip is at least 500 MPa.

Preferably step (c) of conditioning the steel strip produces residual stress of no more than 100 MPa in the strip.

Preferably, step (c) of conditioning steel strip produces residual stress of no more than 90 MPa through the thickness of the strip.

Preferably step (c) of conditioning the steel strip smoothes the surface of the steel strip so that it is suitable for painting in a paint line.

Preferably step (c) of conditioning the steel strip smoothes the surface of the steel strip so that it is sufficiently smooth for painting in a paint line operating at least at 80% of its rated maximum production line speed.

Preferably step (c) of conditioning steel strip

maintains the strip sufficiently flat for painting in a paint line.

The term "sufficiently flat" is understood herein in the context of complying with appropriate national standards, such as Class A and Class B flatness specified in Standard AS/NZ 1365.

Preferably step (c) of conditioning the steel strip includes rolling the strip.

The rolling conditions may be selected as required to condition the surface of the strip and to produce residual stress of no more than 100 MPa.

Preferably the rolling conditions are selected to produce residual stress of no more than 60 MPa.

More preferably the rolling conditions are selected to produce residual stress of no more than 50 MPa.

More preferably the rolling conditions are selected to produce residual stress of no more than 30 MPa.

Appropriate rolling control parameters include, by way of example, any one or more of:

(i) strip extension;

(ii) roll force;

(iii) roll bending; and

(iv) entry and exit tension.

Preferably the metal-coated steel strip has a thickness of no more than 1mm.

More preferably the metal-coated steel strip has a thickness of no more than 0.6mm.

According to the present invention there is also provided a metal-coated, recovery annealed, and therefore high tensile strength, steel strip having a residual stress of no more than 100 MPa and no more than 1 surface defect of the types shown in Figures 1 and 2 per 500 lineal meters of steel strip.

Preferably the steel strip is coated with an aluminium/zinc alloy.

Preferably the aluminium/zinc alloy contains at least 30% by weight aluminium.

Preferably the tensile strength of the steel strip is at least 450 MPa.

More preferably the tensile strength of the steel strip is at least 500 MPa.

According to the present invention there is also provided a painted, metal-coated, recovery annealed, and therefore high tensile strength, steel strip having a residual stress of no more than 100 MPa and no more than 1 surface defect of the type shown in Figures 1 and 2 per 500 lineal meters of strip.

Preferably the steel strip is coated with an aluminium/zinc alloy.

Preferably the aluminium/zinc alloy contains at least 30% by weight aluminium.

Preferably the tensile strength of the steel

strip is at least 450 MPa.

More preferably the tensile strength of the steel strip is at least 500 MPa.

The present invention is described further by way of example with reference to the accompanying drawings of which:

Figures 1 and 2 are photomicrographs of the 2 main types of the surface defect that the present invention is concerned with; and

Figure 3 is a schematic drawing of one embodiment of a continuous production line for producing coated metal strip in accordance with the method of the present invention.

With reference to Figure 3, in use, coils of cold rolled steel strip are uncoiled at an uncoiling station 1 and successive uncoiled lengths of strip are welded end to end by a welder 2 and form a continuous length of strip.

The strip is then passed successively through an accumulator 3, a strip cleaning section 4 and a furnace assembly 5. The furnace assembly 5 includes a preheater, a preheat reducing furnace, and a reducing furnace.

The strip is heat treated in the furnace assembly 5 by careful control of process variables including: (i) the temperature profile in the furnaces, (ii) the reducing gas concentration in the furnaces, (iii) the gas flow rate through the furnaces, and (iv) strip residence time in the furnaces (ie line speed).

The process variables in the furnace assembly 5 are controlled so that there is recovery annealing of the

steel to produce high tensile strength strip, removal of oxide coatings from the surface of the strip, and removal of residual oils and iron fines from the surface of the strip.

The heat treated strip is then passed via an outlet spout downwardly into and through a bath of molten coating metal, typically a aluminium/zinc alloy, held in a coating pot 6 and is coated with metal. The coating metal is maintained molten in the coating pot by use of heating inductors (not shown). Within the bath the strip passes around a sink roll and is taken upwardly out of the bath.

After leaving the coating bath 6 the strip passes vertically through a gas wiping station (not shown) at which its coated surfaces are subjected to jets of wiping gas to control the thickness of the coating.

The coated strip is then passed through a cooling section 7 and subjected to forced cooling.

The cooled, coated strip is then passed through a rolling section 8 that conditions the surface of the coated strip by smoothing the surface of the strip under rolling conditions that produce minimal residual stress, ie no more than 100 MPa, in the strip.

The coated strip is thereafter coiled at a coiling station 10.

The above-described method is characterised by controlling the temperature in the outlet spout of the furnace assembly to be sufficiently high to minimise condensation of metal vapour, typically Zn vapour, from the coating pot 6 on cooler sections of the outlet spout and to maintain the temperature in the outlet spout substantially constant, ie within 20°C. Consequently, there is minimal

deposition of metal/metal oxide particles on strip passing through the outlet spout prior to entering the molten metal bath in the coating pot 6. In situations in which the coating metal is a aluminium/zinc alloy, the temperature of the walls of the outlet spout should be at least 480°C. There are a number of options for achieving required temperature control. These options include appropriate selection of insulation to minimise heat loss and to maintain a uniform temperature in the outlet spout and adjusting heat treatment profiles upstream of the outlet spout at strip changeover.

The rolling section 8 may be of any suitable configuration.

By way of example, the rolling section 8 may be a conventional skin pass rolling assembly, such as a four high mill, of an existing metal coating line which is controlled to operate under rolling conditions that produce required surface conditioning and flatness of the strip, and minimal residual stress.

By way of further example, the rolling section 8 may be a conventional skin pass rolling assembly and downstream leveller assembly of an existing metal coating line which are controlled to operate under rolling conditions that produce required surface conditioning and flatness, and minimal residual stress.

By way of particular example, the rolling section 8 may be a conventional skin pass rolling assembly and cross-bow and anti-camber stages of a conventional downstream leveller assembly of an existing metal coating line which are controlled to operate under rolling conditions that produce required surface conditioning and flatness, and minimal residual stress.

The rolling conditions may be defined by any suitable rolling parameters having regard to the end-use application of the strip and the intermediate processing that may be required to produce the end-use product. In this context, the end-use application and required intermediate strip processing (such as painting the strip) may make it necessary for the rolling conditions to take into account other properties, such as strip flatness.

Where strip flatness is a particular issue, as typically would be the case where the strip is to be painted, it may be appropriate to carry out a two step rolling operation with the second step being principally concerned with producing flat strip while maintaining less than 100 MPa residual stress.

Typically, the rolling conditions in the rolling section 8 may be defined by reference to the parameters of strip extension, roll force, roll bending and strip tension (in situations where the rolling section 8 includes entry/exit bridles).

The above-described rolling conditions are typical rolling conditions to produce surface conditioning and flatness required for metal-coated steel strip in the form of aluminium/zinc coated steel strip that is suitable for use as a feedstock for a paint coating line operating at least at 50m/min, more preferably at least 100m/min, and more preferably at least 150m/min.

The applicant has found in a trial that the above-described method consistently produced high tensile steel strip having no more than 1 defect of the type shown in Figures 1 and 2 per of 500 lineal meters of strip. Previously, prior to the present invention, the applicant was experiencing, on average, 1 such surface defect per 100 lineal meters of strip.

Many modifications may be made to the preferred embodiment described above without departing from the spirit and scope of the present invention.

Furthermore, whilst the preferred embodiment of the method includes rolling metal-coated steel strip, the present invention is not so limited and extends to any suitable method of conditioning the surface of strip by smoothing the surface without producing residual stress in excess of 100 MPa.

CLAIMS

1. A method of producing a metal-coated, recovery annealed, and thereby high tensile strength, steel strip which includes the steps of successively passing the steel strip through a heat treatment furnace, a bath of molten coating metal, and a conditioning station, and:

(a) heat treating the steel strip in the heat treatment furnace;

(b) hot-dip metal coating the strip in the bath of molten coating metal and thereby forming a metal coating on the steel strip; and

(c) conditioning the surface of the metal-coated steel strip at the conditioning station by smoothing the surface of the strip, and

which method is characterised by controlling the temperature of an outlet end section of the heat treatment furnace to be (i) sufficiently high to minimise condensation of metal vapour in the outlet end section and/or (ii) substantially constant to minimise destabilisation of metal/metal oxide deposits on the walls of the outlet end section that could release deposited material onto strip passing through the outlet end section.

2. The method defined in claim 1 includes keeping the temperature of the outlet end section of the heat treatment furnace sufficiently high by controlling the upstream operating conditions within the furnace.

3. The method defined in claim 1 or claim 2 includes keeping the temperature of the outlet end section of the heat treatment furnace substantially constant by controlling the upstream operating conditions within the

furnace.

4. The method defined in any one of the preceding claims wherein, in a situation in which there is a need to change the heat treatment profile of strip in order to produce strip that has different mechanical properties to immediately preceding strip, the method includes controlling the heat treatment profile of the strip in one or more sections of the furnace that are upstream of the outlet end section to adjust the mechanical properties of the strip as required and without substantially changing the temperature in the outlet end section.

5. The method defined in any one of the preceding claims wherein the metal of the metal coating is a aluminium/zinc alloy and the metal/metal oxide deposits are Zn/ZnO deposits.

6. The method defined in claim 5 wherein the aluminium/zinc alloy contains at least 30% by weight aluminium.

7. The method defined in claim 5 includes controlling the wall temperature of the outlet end section of the heat treatment furnace to be at least 450°C.

8. The method defined claim 7 includes controlling the wall temperature of the outlet end section of the heat treatment furnace to be at least 480°C.

9. The method defined in any one of the preceding claims includes controlling the wall temperature of the outlet end section of the heat treatment furnace to be with in a temperature range of 20°C.

10. The method defined in any one of the preceding claims wherein the tensile strength of the steel strip is

at least 500 MPa.

11. The method defined in any one of the preceding claims wherein step (c) of conditioning the steel strip produces residual stress of no more than 100 MPa in the strip.

12. The method defined in any one of the preceding claims wherein step (c) of conditioning steel strip produces residual stress of no more than 90 MPa through the thickness of the strip.

13. The method defined in any one of the preceding claims wherein step (c) of conditioning the steel strip smoothes the surface of the steel strip so that it is suitable for painting in a paint line.

14. The method defined in any one of the preceding claims wherein step (c) of conditioning the steel strip smoothes the surface of the steel strip so that it is sufficiently smooth for painting in a paint line operating at least at 80% of its rated maximum production line speed.

15. The method defined in any one of the preceding claims wherein step (c) of conditioning steel strip maintains the strip sufficiently flat for painting in a paint line.

16. The method defined in any one of the preceding claims wherein step (c) of conditioning the steel strip includes rolling the strip.

17. A metal-coated, recovery annealed, and therefore high tensile strength, steel strip having a residual stress of no more than 100 MPa and no more than 1 surface defect of the types shown in Figures 1 and 2 per 500 lineal meters of steel strip.

18. The strip defined in claim 17 wherein the metal coating includes an aluminium/zinc alloy.

19. The strip defined in claim 18 wherein the aluminium/zinc alloy contains at least 30% by weight aluminium.

20. The strip defined in any one of claims 17 to 19 wherein the tensile strength of the steel strip is at least 450 MPa.

21. A method of producing a painted, metal-coated, recovery annealed, and thereby high tensile strength, steel strip which includes the steps of successively passing the steel strip through a heat treatment furnace, a bath of molten coating metal, a conditioning station, and a paint line and:

(a) heat treating steel strip in the heat treatment furnace;

(b) hot-dip metal coating the strip in the bath of molten coating metal and thereby forming a metal coating on the steel strip;

(c) conditioning the surface of the metal-coated steel strip at the conditioning station by smoothing the surface of the strip; and

(d) forming a paint coating on the conditioned strip in the paint line, and

which method is characterised by controlling the temperature of an outlet end section of the heat treatment furnace to be (i) sufficiently high to minimise condensation of metal vapour in the outlet end section

and/or (ii) substantially constant to minimise destabilisation of metal/metal oxide deposits on the walls of the outlet end section that could release deposited material onto strip passing through the outlet end section.

22. A painted, metal-coated, recovery annealed, and therefore high tensile strength, steel strip having a residual stress of no more than 100 MPa and no more than 1 surface defect of the type shown in Figures 1 and 2 per 500 lineal meters of strip.

23. The painted strip defined in claim 22 wherein the metal coating includes an aluminium/zinc alloy.

24. The painted strip defined in claim 23 wherein the aluminium/zinc alloy contains at least 30% by weight aluminium.

25. The painted steel strip defined in any one of claims 22 to 24 wherein the tensile strength of the steel strip is at least 450 MPa.

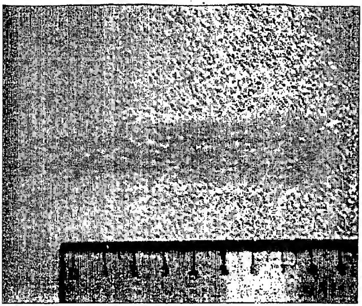


FIG. 1.

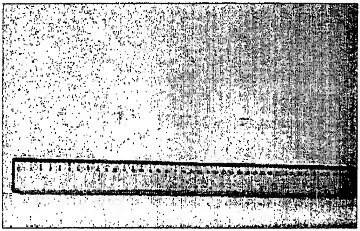


FIG. 2a

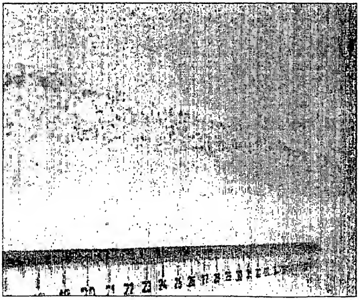


FIG. 2b

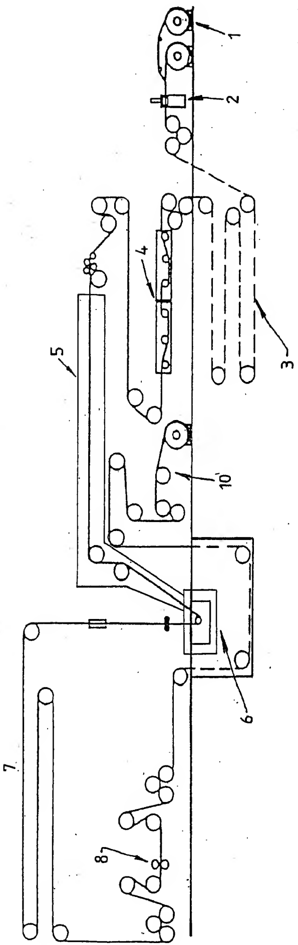


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2004/000346

A.	CLASSIFICATION OF SUBJECT MATTER
Int. Cl. 7:	C21D 9/56, 11/00, C23C 2/40, 2/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C21D 9/56, 11/00, C23C 2/40, 2/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI: IPC marks + KEYWORDS (zinc, strip, vapour, condense, temperature, insulate)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, X	US 6706331 B (CLANCY ET AL) 16 March 2004 Whole document	1-4, 7-16, 21
X	Derwent Abstract Accession No. 2000-119018/11, Class M13 JP 11-286762 A (NIPPON STEEL CORP) 19 October 1999 & JP 11-286762 A Whole document	1, 16
A	US 4557953 A (BOSTON ET AL) 10 December 1985 Whole document	1-25
A	Derwent Abstract Accession No.97-115655/11, Class M13 JP 09-003552 A (NIPPON STEEL CORP) 7 January 1997 Abstract	1-25

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 May 2004	12 MAY 2004

Name and mailing address of the ISA/AU

AUSTRALIAN PATENT OFFICE
PO BOX 200, WODEN ACT 2606, AUSTRALIA
E-mail address: pct@ipaustralia.gov.au
Facsimile No. (02) 6285 3929

Authorized officer

THARU FERNANDO
Telephone No : (02) 6283 2486

C (Continuation).	DOCUMENTS CONSIDERED TO BE RELEVANT	
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Derwent Abstract Accession No. 95-012233/02, Class M13 JP 06-299310 A (PRAXAIR ST TECHNOLOGY INC) 25 October 1994 Abstract	1-25
A	US 6093452 A (ISHII ET AL) 25 July 2000 Whole document	1-25

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
JP	11286762	NONE					
US	6706331	AU	43836/01	CN	1353212	EP	1336666
		NZ	514712	US	2003152796		
US	4557953	AU	45354/85	BR	8503602	CA	1263930
		EP	0172681	ES	8607419	FI	852937
		JP	61041754				
JP	09003552	NONE					
JP	06299310	NONE					
US	6093452	CA	2230369	JP	10237610	JP	11100649
		JP	11100650	NZ	329844	US	6315829

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX